

THE IMPACT OF DIELECTRIC CONSTANT MODEL AND SURFACE REFERENCE ON DIFFERENCES BETWEEN SMOS AND AQUARIUS SEA SURFACE SALINITY

E. P. Dinnat^(1,2), J. Boutin⁽³⁾, X. Yin⁽³⁾, D. M. Le Vine⁽²⁾

⁽¹⁾Chapman University, Orange, CA, U.S.A.

⁽²⁾NASA GSFC, Cryospheric Sciences Laboratory, Greenbelt, MD, U.S.A

⁽³⁾Laboratoire d'Océanographie et du Climat: Expérimentations et Approches Numériques,
CNRS/IRD/UPMC/MNHN, Paris, France

1. INTRODUCTION

Two ongoing space missions share the scientific objective of mapping the global Sea Surface Salinity (SSS), yet their observations show significant discrepancies. ESA's Soil Moisture and Ocean Salinity (SMOS) and NASA's Aquarius use L-band (1.4 GHz) radiometers to measure emission from the sea surface and retrieve SSS.

Significant differences in SSS retrieved by both sensors are observed, with SMOS SSS being generally lower than Aquarius SSS, except for very cold waters where SMOS SSS is the highest overall. Figure 1 is an example of the difference between the SSS retrieved by SMOS and Aquarius averaged over one month and 1 degree in longitude and latitude. Differences are mostly between -1 psu and +1 psu (psu, practical salinity unit), with a significant regional and latitudinal dependence. We investigate the impact of the vicarious calibration and retrieval algorithm used by both mission on these differences.

2. DIFFERENCES IN SMOS AND AQUARIUS ALGORITHMS

One notable difference between the two missions is the dielectric constant model used for the sea water. SMOS uses the model of Klein and Swift (1977) [1] and Aquarius uses the model of Meissner and Wentz (2012) [1]. Although similar, the two models are different, especially in cold water (Fig. 2, left). The dielectric constant model is used at two stages of the data processing: 1/ to calibrate the instruments by comparing radiometric measurements to forward model simulations, and 2/ to invert SSS from surface brightness temperature (Tb). In order to assess the impact of the dielectric constant model on the differences observed in SSS between SMOS and Aquarius, we reprocess the Aquarius data using the model used for SMOS. Specifically, we use the Klein and

Swift model for the reference ocean used in the calibration of Aquarius; then we used it again, keeping all other factors the same, to perform the inversion to obtain SSS.

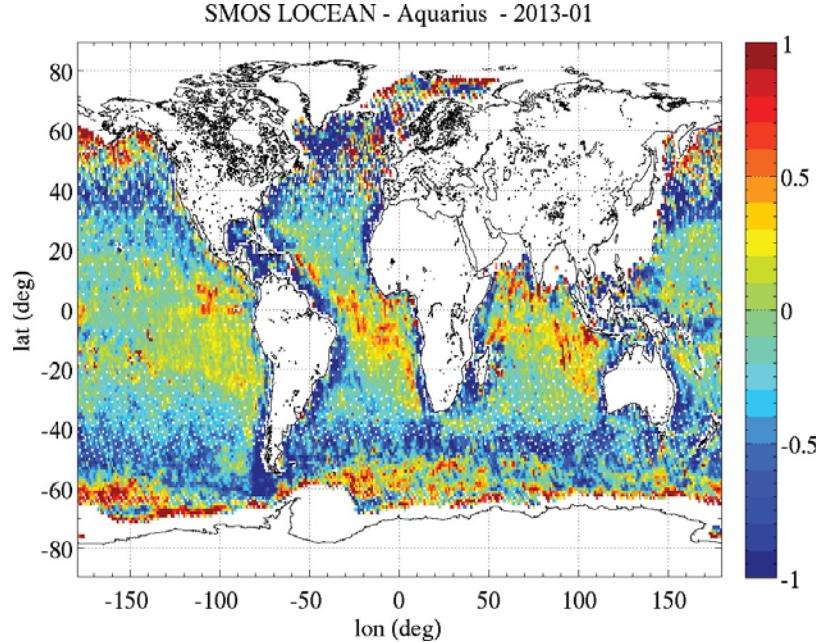


Figure 1: Global map of the difference in SSS between SMOS Level 3 (LOCEAN) product and Aquarius Level 2 product binned monthly at 1 deg x 1 deg spatial resolution, for the month of January 2013. The colorscale is saturated between - 1 psu and + 1 psu.

Another difference between the two missions concerns the vicarious calibration. SMOS Ocean Target Transformation (OTT) uses comparisons between measured Tb's and forward model simulations over a limited region in the Pacific Ocean to remove biases in its field of view [3]. Aquarius performs a similar comparison at global scale [4] . The reference SSS for the simulations is the World Ocean Atlas (2009) for SMOS [5], the HYbrid Coordinates Ocean Model (HYCOM) for Aquarius [6]. We assess the difference in the reference salinity fields that are used to calibrate both instruments.

3. RESULTS

The two dielectric constant models exhibit differences of less than a percent, but this uncertainty results in differences in Tb of the order of a few tenths of a Kelvin (Fig. 2, left). The differences between Aquarius original data and data reprocessed with SMOS permittivity model vary mostly within 0.5 psu at global scale, with a few larger regional variations, for example in cold waters (Fig. 2, right). Seasonal variations occur at mid and high

latitudes. Aquarius and SMOS differences exhibit dependence in temperature (Fig. 1), which is reduced when Aquarius data are reprocessed with SMOS’s permittivity model. We find that the permittivity model explains part of the differences between both instruments, particularly in cold waters, but some significant disagreement remains.

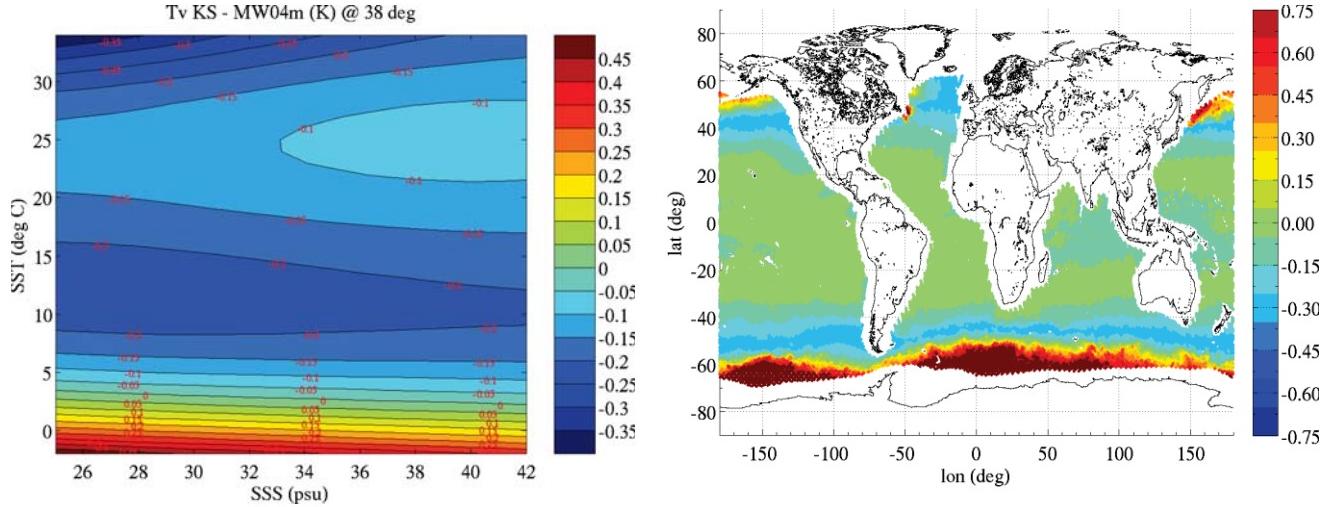


Figure 2: (left) Tb difference at vertical polarization for a smooth sea surface (i.e. Fresnel reflectivity) caused by differences in sea water dielectric constant model, computed between KS77 [1] and MW12 [1] models, versus Sea Surface Salinity (SSS) in psu and Sea Surface Temperature (SST) in Celsius. The incidence angle is 38 degrees. (right) Global map of the difference in Aquarius SSS (psu) for one week in early February 2012 caused by differences in dielectric constant models. The difference is between our reprocessed Aquarius data and the official Level 2 product. We compute the reprocessed data using the KS77 model for the calibration and the inversion of the Level 2 data into SSS. The official product uses MW12 for the calibration and inversion.

The differences in the reference SSS field are most of the time relatively small, but not always negligible (Fig. 3, left). Large regions of the ocean exhibit differences of just 0.1 K or less. However, regionally, differences can be larger (1 psu or more) and are variable in time. The difference in the region used for SMOS calibration varies between -0.1 psu and +0.05 psu since Aquarius started operating (Fig. 3, right).

1. CONCLUSION

We assess the impact of the difference in dielectric constant model and reference salinity field on the difference in retrieved SSS between SMOS and Aquarius. We find that the dielectric constant has a large impact mostly in cold waters. Differences in reference SSS fields are small in general, but could explain biases of 0.1 psu at times. This

research is ongoing and will address the differences in reference fields for the sea surface temperature. Ultimately, a processing similar to SMOS will be applied to Aquarius data to assess the impact on SSS retrieval of several of the differences in the two instruments algorithms.

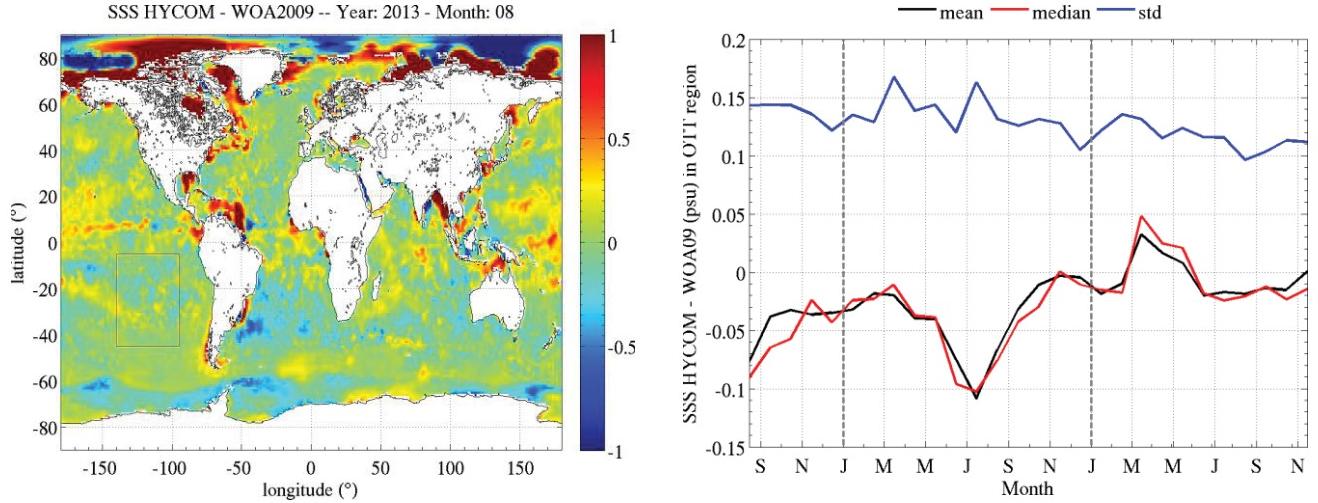


Figure 3: (left) Global monthly map of the differences in SSS (psu) between the two different ancillary products used in the calibration of Aquarius and SMOS. The difference is between the HYCOM model (used for Aquarius) and the World Ocean Atlas 2009 (used for SMOS). The red square in the south of the Pacific Ocean off the coast of South America illustrates the region used for the calibration of SMOS SSS product (i.e. the Ocean Target Transformation). (right) Time series of the average (mean and median) and standard deviation of the difference in SSS between HYCOM and WOA09 over the Ocean Target Transformation (OTT) region since the start of the Aquarius mission (Aug 2011 - Nov 2013). The vertical dashed lines part the different years.

2. REFERENCES

- [1] L. A. Klein and C. T. Swift, "An improved model for the dielectric constant of sea water at microwave frequencies," *IEEE Transactions on Antennas and Propagation*, vol. AP-25, no. 1, pp. 104–111, 1977.
- [2] T. Meissner and F. J. Wentz 2012, "The Emissivity of the Ocean Surface Between 6 and 90 GHz Over a Large Range of Wind Speeds and Earth Incidence Angles", *IEEE Trans. Geosci. Remote Sens.*, vol. 50, no. 8, pp. 3004–3026, Aug. 2012.
- [3] X. Yin, J. Boutin and P. Spurgeon, "Biases Between Measured and Simulated SMOS Brightness Temperatures Over Ocean: Influence of Sun," *Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Journal of*, vol.6, no.3, pp.1341-1350, June 2013.
- [4] J. Piepmeier et al., "Aquarius radiometer post-launch calibration for product version 2," Aquarius Project Document: AQ-014-PS-0015, Tech. Rep. AQ-014-PS-0015, NASA and CONAE, 2013.
- [5] J. Antonov, D. Seidov, T. Boyer, R. Locarnini, A. Mishonov, H. Garcia, O. Baranova, M. Zweng, and D. Johnson, "World ocean atlas 2009 volume 2: Salinity," in NOAA Atlas NESDIS 69, S. Levitus, Ed. Washington, D.C., USA: U.S. Government Printing Office, p. 184, 2012.
- [6] E. P. Chassignet et al., "The HYCOM (HYbrid Coordinate Ocean Model) data assimilative system," *Journal of Marine Systems*, vol. 65, Issues 1–4, pp. 60-83, March 2007.